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The Effects of Repeat Testing on Performance Scores Utilizing the Isostation B-200

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THE EFFECTS OF REPEAT TESTING ON PERFORMANCE SCORES UTILIZING THE ISOSTATION B-200

by

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An Independent Study

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Department of Physical Therapy

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This Independent Study, submitted by Stephanie D. Kyes in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

Thomas Mohr
(Faculty Preceptor)

Thomas Mohr
(Graduate School Advisor)

Thomas Mohr
(Chairperson, Physical Therapy)

PERMISSION

Title	The Effects of Repeat Testing on Performance Scores Utilizing the Isostation B-200
Department	Physical Therapy
Degree	Master of Physical Therapy

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Signature Stephanie D. Kyes

Date 4-17-95

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To my parents
and
my best friend, RKM

ABSTRACT

The purpose of this experimental study was twofold: 1) to determine if there was a significant increase in performance, or learning effect, between the first and second test sessions on the Isostation B-200 for normal subjects, and 2) if so, was there a specific percentage of increase that can be attributed as a learning effect for each age, gender, or activity level.

Twenty-two subjects (8 men, 14 women) with no prior history or treatment for low back pain were utilized in this study. All subjects were tested in two positions. First, in an upright standing position and second, in twenty degrees of trunk flexion. The subjects were asked to perform maximal isometric contractions in each direction of the sagittal, coronal, and transverse planes for both test positions. Subjects were retested between forty-eight and ninety-six hours post-initial testing.

Several research articles have indicated the presence of a learning effect, but very few have shown a statistically significant increase in performance. The results of this research have shown significant increases for all trunk motions between first and second test sessions with the trunk in twenty degrees of flexion, with an average increase of 16.10%. A significant increase for trunk flexion and extension was also found in the upright position, with an average increase in performance of 9.03% for all motions. This study also indicates that their is a greater amount of learning displayed in females as compared to males.

Based upon this study, clinicians should realize that increases in torque production ranging from zero to fifteen percent, between the first and second test trials on the Isostation B-200, may be due to a learning effect.

LITERATURE REVIEW

INTRODUCTION TO THE B-200

Low back pain is a nationwide medical and socioeconomic problem. In fact, it is estimated that low back pain will affect eight out of ten people in the United States at some point in their life.[1] Because of this high prevalence and the invasive treatment necessary for many people suffering from low back pain (LBP), the cost has risen at an alarming rate. The direct cost to society is estimated at twenty billion dollars per year, and the total cost (including indirect costs of work loss and transfer payments) is said to exceed fifty billion dollars per year.[1,2] In order to decrease this cost, it is necessary for health care professionals to perform accurate and efficient evaluations of the spine.

The challenge of evaluating spine musculature is the lack of a control for comparison. When testing the extremities, the contralateral uninjured joint is used for comparison. Such a comparison is not possible for the spine. As a result, much research and technology has been devoted to developing a machine that will produce objective findings on the functional capacities of trunk musculature.

At present, there are three competing methods for evaluating low back function: isometric, isokinetic, and isoinertial.[3] Isometric, or static, strength testing is when no muscle shortening takes place and no work is performed. It is the earliest and simplest approach and has proven to be a safe and reliable test. Isometric contraction in testing back function is used mainly for testing flexion, extension, and lifting.[4] The primary complaint regarding isometric testing is that it does not accurately reflect "normal" activity because it does not involve movement.

This led to the development of isokinetic machines that measure force, or torque, throughout a range of motion while keeping a constant, preset velocity. The best known isokinetic trunk testing machine is the Cybex II (Cybex, Inc., Lumex, NY). It has proven advantageous for strength training because it places muscles on maximum tension throughout the range of motion (ROM).[3] However, when comparing isokinetic results in relation to muscle fatigue and endurance, isokinetic measures have been quoted as "reducing the practicality of the results because movements in real life seldom have constant velocity".[5]

In order to simulate real life situations in both testing and exercise programs, isoinertial machines were designed. An isoinertial contraction is one in which the muscles contract against a constant load. If the torque generated by the muscle contraction is equal to or less than the resistance, then the length will not change; but if the torque is larger than the resistance, then the length will change and the excess torque will determine the body part's acceleration.[5] An immense interest in isoinertial testing has been prompted because many industrial tasks, and real-life tasks for that matter, require dynamic contraction with time-varying trunk velocity.

The Isostation B-200 (Isotechnologies, Inc., Hillsborough, NC) was first introduced in 1987 and is the most common and widely used isoinertial machine. The B-200 is a triaxial dynamometer that is unique in its capability of simultaneously measuring angular position, velocity, and torque about the three primary axes of the low back - rotation, lateral flexion, and flexion/extension.[6-10] The B-200 provides the ability to test the patient's flexibility, isometric strength, and resisted dynamic strength.[6]

The B-200 has been used in the following situations: rehabilitation, diagnostic purposes, developing training programs, therapeutic exercise, preemployment screening, and assessment of effort.[4] Patients can use the dynamometer for rehabilitation in circumstances in which strengthening in selective, specific planes (such as rotation) is appropriate.[1] For example, if an individual's results show a deficit in strength or velocity at a certain portion of the lateral flexion cycle, efforts can be directed at strengthening the specific set of muscles involved during that motion. Repeat assessment with the dynamometer provides visual evidence of improvement and positive feedback to individuals to continue working on their rehabilitation goals. Also, if an individual is able to see objective findings it may improve compliance with therapy for those "unmotivated" patients. On the other hand, if the results do not show an improvement, it allows the therapist to reevaluate the treatment and strengthening program.

Dynamometers are also useful in the management of a patient with a low back injury. After an individual has recovered from the acute stage of injury, dynamic assessment of lumbar function can be performed and a specific strengthening program designed. Since most individuals will not have undergone a preinjury baseline examination, normative databases have been developed for general comparison purposes.[1]

RELIABILITY AND VALIDITY

Reliability is the characteristic of a test to provide consistent measurements. Rytokoski et al[11] found both intra- and interrater reproducibility on the B-200 to provide good to excellent results for isometric strength of trunk muscles, isoinertial (dynamic) testing in the primary axis (flexion/extension), and for the two functional indices of the isoinertial test (power index and work index). They did not find as good of results for trunk mobility for both intra- and interrater comparisons, however. Only the reliability for lateral flexion and the sum of all range of motion measurements was high enough to allow its use in reporting mobility data.

The ability of a test to measure what it claims to measure is termed validity. According to Newton et al,[12] "there is no direct evidence that isokinetic or isoinertial performance provides a valid measure of actual muscle strength or a deficit in LBP. Rather it measures what patients are doing with their muscles. Isokinetic and isoinertial measures should be interpreted as "measures of performance." Although there is no direct relationship between iso-measurements and muscle strength, there is some indirect evidence. Significant correlations between electromyographic activity of back muscles and spinal loading and lifting activities have been reported.[13]

Routine calibration of torque measurements are performed on both isokinetic and isoinertial machines. Readings from the Cybex II are taken at a velocity of 12 degrees/second (so slow it is almost isometric) and are found to be highly accurate and consistent. Parnianpour et al[5] established the validity and reliability of the B-200 in their study by two methods: 1)adding calibrated weights at a known distance off the center of rotation of each axis and regressing the measured torque with the weights; and 2) aligning the goniometer's axis of rotation with the machine's axis of rotation and again use linear regression. This procedure was repeated twice with resulting correlation coefficients greater than 0.99, indicating a high degree of reliability.

In another study, Parnianpour et al[8] concluded that the Isostation B-200 is a valid instrument for measurement of strength and ROM of the trunk and that the results are highly reproducible. The software for the Isostation B-200 provides the user with the opportunity to verify that selected performance measurements are within factory specifications.[14]

DEFINITION OF MOTOR LEARNING

Variations in intra-subject measurements can be the result of many factors. First, these variations can be caused by momentary changes in the subject's internal state.[15] For example, attention, fatigue, and boredom may all cause differences from one test to another. Other variations are caused by systemic changes within the subject.[15] Examples of this would include the level of learning of the task and changes in the person's strategy on how to complete the task.

These variations can be minimized by controlling the test situation. Researchers typically use tape-recorded instructions to eliminate deviations in what is said by the examiner. Silenced or sound-deadened testing rooms, as well as testing subjects one at a time, decrease variability.[15]

The preceding protocol tends to reduce the sources of variability in an experiment, thus allowing the effects of the study to be more easily observed. The drawback is that the resulting situation is less clinical and, therefore, the measurements are not as directly related to practical settings.

The topic of this research project is the effect that learning has on subsequent strength testing. Motor learning can be defined as the set of processes leading to relatively permanent changes in motor response based upon practice and experience.[15] This definition can be broken down into four aspects. First, is the fact that learning is a process. A process is a set of events or occurrences that, when added together, lead to a particular behavior.[15] In motor learning, processes contribute to changes in motor behavior as a result of practice. The focus is on the changes that occur in the organism which allow it to perform differently after practice. Learning, then, is not the behavioral change; rather, it is the set of processes that lead to the change. Second, motor learning is a direct result of practice or experience, ruling out factors such as maturation and growth.[15]

Third, motor learning is usually not directly observable.[15] The processes leading to changes in behavior are internal and are usually not available for direct examination. Instead, one must infer that learning occurred on the basis of the changes in behavior that can be observed. This feature of motor learning makes it particularly difficult to study. Experiments must be designed so that the observed changes in behavior allow the logical conclusion that there were associated changes in some internal state.

Finally, learning is assumed to produce relatively permanent changes in skilled behavior.[15] Those changes in behavior which are caused by easily reversible alterations in mood, motivation, or internal states (example, hunger) will not be classified as learning. When you practice and learn, we can say that you will never be the same as you were before. Learning has the effect of changing you and your behavior, if only slightly, in a relatively permanent way. Richard Schmidt[15] uses the following analogy to make this point: "If I cool water, I find that it becomes solid (ice); but I can reverse the effect completely to produce water again simply by warming it. Not so with boiling an egg. Boiling an egg for 10 minutes will produce changes that are not reversible when the egg is cooled." Therefore, a relatively permanent change has been made in the egg.

Exactly how permanent is "relatively permanent"? This is a very general term, and scientists studying learning are rarely clear about it. The only definite assumption that can be made is that learning should have some lasting effect.[15]

MOTOR LEARNING AND THE B-200

Many studies involving isokinetic and isoinertial testing have claimed as much as a 15-20% increase in performance upon retesting.[4] McIntyre[9] concluded that to obtain a stable measure of the average torques for isometric trunk flexion, "more than one trial should be performed with the first trial being discarded from the analysis". However, he also stated that only one trial is required to obtain a stable measure of the maximum torques during isometric trunk flexion over a 5 second time interval.

Cooke et al[16] retested subjects between two and four weeks post-intitial testing. Utilizing a repeated measures analysis of variance, they reported a significant increase in performance ($p<0.05$) between first and second test sessions for their control group, but did not state the percent of increase that was present. There was not a significant increase between second and third test sessions for the control group. A ten percent increase in isometric performance was reported for the patient population for both retest sessions.

Rytokoski et al[11] also stated an increase in the maximum isometric strength measurement between first and second sessions, even though they found intra- and interrater reliability to provide good to execellent results. They described this general increase as a "training" effect.

In their abstract, Montain et al[17] indicated that an individual's isometric test score on the Isostation B-200 will range from 6.3-9.5% between test days. They found significant increases in performance for bilateral trunk rotation between the first and second test dates, and for trunk flexion when the results from days one and two are compared with days three and four.

It has been reported that the greatest learning effect takes place between the first and second test sessions, and that the second test results (taken on a separate day), should be used as the baseline data.[4,9,11,12, 16-19] Very few studies allow for this, as it does not seem to be readily adaptable into the clinical setting where time demands are always pressing.

Based on the available literature, it appears there is little information available for the clinician to determine the normal percent increase in performance that should be expected (due to learning the testing technique) when retesting subjects utilizing the Isostation B-200.

Therefore, the purpose of this experimental study is twofold: 1) to determine if there is a significant increase in performance, or learning effect, between the first and second test sessions on the Isostation B-200 for normal subjects; and 2) if so, is there a specific percentage of increase that can be attributed as a learning effect for each age, gender, or activity level.

METHODOLOGY

SUBJECTS

Tables 1 and 2 represent the demographic information gathered from the subjects. The subjects included 22 healthy volunteers (8 men, 14 women) ranging in age from 21 to 54 years with no prior history or treatment for LBP. Subjects were placed into the appropriate age category (21-30; 31-54) with 5 men and 9 women in the first group, and 3 men and 5 women in the second. Subjects were recruited on a volunteer basis from the Medical Center Rehabilitation Hospital and the University of North Dakota. They did not have prior experience on the Isostation B-200, with the exception of one physical therapist. They were asked not to initiate any new physical training program during the course of their participation in this study.

INSTRUMENTATION

The Isostation B-200 was used to collect the maximal, voluntary, isometric strength of the trunk musculature. The B-200 is a triaxial dynamometer that measures angular position, angular velocity, and torque about the three primary axes of movement for the low back. The machine is interfaced to a personal computer via an analog to digital convertor board. The computer is designed to control the resistance about each axis. Electronically regulated hydraulic pumps associated with each axis provide the resistance. The software collects and displays calibrated performance information for each axis. All data was stored on floppy disk.

Table 1. Characteristics of Subjects

Subjects	Gender	Height (in.)	Weight (lbs.)	Age (yr.)	Recreational Activity (f)	Trunk Ex. (f)
1	m	69	184	27	2	3
2	m	69	145	21	3	4
3	m	72	160	21	1	0
4	m	69	180	21	2	3
5	f	66	170	31	0	0
6	m	70	170	31	2	0
7	f	64	125	25	2	4
8	f	62	205	54	0	0
9	f	65	130	22	2	1
10	f	65	123	23	2	4
11	m	70	157	25	2	4
12	m	69	140	35	2	2
13	f	66	150	45	1	0
14	f	64	120	26	4	4
15	f	62	120	25	3	4
16	f	64	130	21	3	3
17	f	68	155	28	1	1
18	f	64	140	3	1	0
19	f	71	155	33	4	0
20	f	67	130	21	3	4
21	f	63	120	22	3	1
22	m	72	180	34	1	2

Table 2. Descriptive Statistics of Subjects			
	Mean	SD	Range
Age (yr)	28.23	8.37	21-54
Height (in)	66.86	3.18	62-72
Weight (lbs)	149.50	24.35	120-205
Recreational Activity	2.00	1.11	0-4
Trunk Exercise	2.05	1.68	0-4

DESIGN AND PROCEDURE

The subjects were asked to complete a consent form, a health history form, and an activities questionnaire prior to their first test session (Appendix). Demographic information, such as age, weight, height, and gender were collected. The subjects were introduced to the Isostation B-200 by one of two project directors and any questions were answered at this time. Subjects were then positioned in the B-200 and firmly stabilized by chest and pelvic pads (Figures 1 and 2). Additional straps secured the knees, thighs, and thorax, all according to the manufacturer's protocol. All subjects received a one repetition warm-up session prior to testing, as this is part of the standard protocol used in this facility. They were tested in two positions. First, in an upright, standing position and second, locked into 20 degrees of flexion. The subject was asked, via audiotape, to perform 2 maximal isometric contractions in each direction of the sagittal, coronal, and transverse planes for both test positions (24 total contractions). The subject was asked to exert steady maximum effort until he/she was asked to relax. To ensure the safety of the subject, each subject was warned against jerky exertion. Subjects were retested between 48 and 96 hours post-initial testing to allow recovery from any post-exercise muscle soreness that may have occurred. An audiotape was not used during the second test session, instead, instructions were given by one of the project directors. Also, only one maximal contraction for each direction was required for both test positions during the retest (12 total contractions). The differences between the initial and retest protocols were a result of utilizing a test procedure currently in use to test patients at this clinical facility.

Figure 1. Subject stabilized in the upright position on the Isostation B-200.

Figure 2. Subject stabilized in the flexed position on the Isostation B-200.p

DATA ANALYSIS

The B-200 software was used to obtain the average maximum torque for the initial test session (two repetitions) and the maximum torque for the retest session (one repetition). All data was analyzed utilizing the SPSSX^{TM} statistical software package. A paired t-test was performed to compare torque values between the initial and retest data. An alpha level of .05 was established prior to the study, and two-tailed tests were employed.

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*SPSSX^{TM} Inc., 444 North Michigan Ave., Chicago, IL 60611

RESULTS

Tables 3 and 4 give the descriptive statistics for changes in isometric torque for all subjects in the upright and twenty degree flexed positions, respectively. Using a paired t-test, a significant increase ($p<.05$) was found for all motions in the flexed position and for trunk flexion and extension in the upright position. The greatest increase in performance was in trunk extension equalling 24.50% in the upright position and 26.07% in the flexed position. The percent change in the upright position ranged from -2.20% to 24.50%, with an average increase of 9.03%. The range of increased performance in the twenty degree flexed position was from 8.64% to 26.07%, with the average being 16.19%.

Tables 5 and 6 show the statistics for males and females in the upright position. The males showed a significant increase in flexion and extension, while females exhibited a significant increase in flexion, extension, and left lateral flexion. In the twenty degree flexed position (Tables 7 and 8), males demonstrated a significant increase in extension and left lateral flexion, while females displayed a significant increase in all motions.

Figures 3 and 4 compare the percent changes in torque between all the subjects (n=22), male subjects (n=8), and female subjects (n=14). In all positions, the female subjects showed an increase in strength, whereas the male subjects increased strength in all movements except right rotation where they decreased their torque production. In analyzing the raw data, this

Table 3. Isometric Torque for Trunk Motions in the Upright Position for Initial and Retest Dates

Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\bar{x}$	s	$\bar{x}$	s				
Right Rotation	22	43.21	20.11	42.28	20.69	-2.20	8.15-80.50	.42	.679
Left Rotation	22	44.61	18.00	47.53	22.24	6.55	15.45-84.55	-1.25	.227
Flexion	22	89.35	45.38	106.45	45.41	19.14	41.80-217.80	-6.52	.000
Extension	22	114.90	46.06	143.05	55.56	24.50	44.00-248.60	-5.74	.000
R. Lat Flexion	22	98.42	40.76	100.51	40.83	2.12	54.70-188.70	-.97	.344
L. Lat Flexion	22	94.74	34.77	98.60	35.36	4.07	48.40-163.30	-1.54	.139

Table 4. Isometric Torque for Trunk Motions in the Flexed Position for Initial and Retest Dates

Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\overline{x}$	s	$\overline{x}$	s				
Right Rotation	22	48.87	21.27	55.75	23.44	14.08	22.80-99.20	-2.75	.012
Left Rotation	22	48.05	19.12	55.37	20.97	15.23	17.90-96.00	-3.38	.003
Flexion	22	95.20	52.88	110.30	43.53	15.10	44.00-237.60	-3.61	.002
Extension	22	121.00	45.56	152.55	59.95	26.07	12.10-255.20	-5.11	.000
R. Lat Flexion	22	101.05	40.96	109.78	39.72	8.64	52.30-176.00	-4.39	.000
L. Lat Flexion	22	92.90	35.14	109.63	36.86	18.01	46.00-174.40	-5.47	.000

Table 5. Isometric Torque in Males in the Upright Position for Initial and Retest Dates

Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\bar{x}$	s	$\bar{x}$	s				
Right Rotation	8	65.57	9.28	61.69	10.31	-6.29	44.70 -80.50	1.23	.257
Left Rotation	8	63.12	13.75	66.37	19.00	5.15	30.90 - 84.55	-.68	.520
Flexion	8	132.69	46.02	153.86	35.51	15.96	50.60 - 217.80	-4.64	.002
Extension	8	158.40	41.79	203.91	40.34	28.73	84.70 - 248.60	-5.60	.001
R. Lat Flexion	8	145.38	26.77	147.28	26.04	1.31	101.45 -188.70	-.34	.743
L. Lat Flexion	8	132.99	19.48	133.38	31.01	.29	72.15 - 163.30	-.07	.949

Table 6. Isometric Torque in Females
in the Upright Position for Initial and Retest Dates

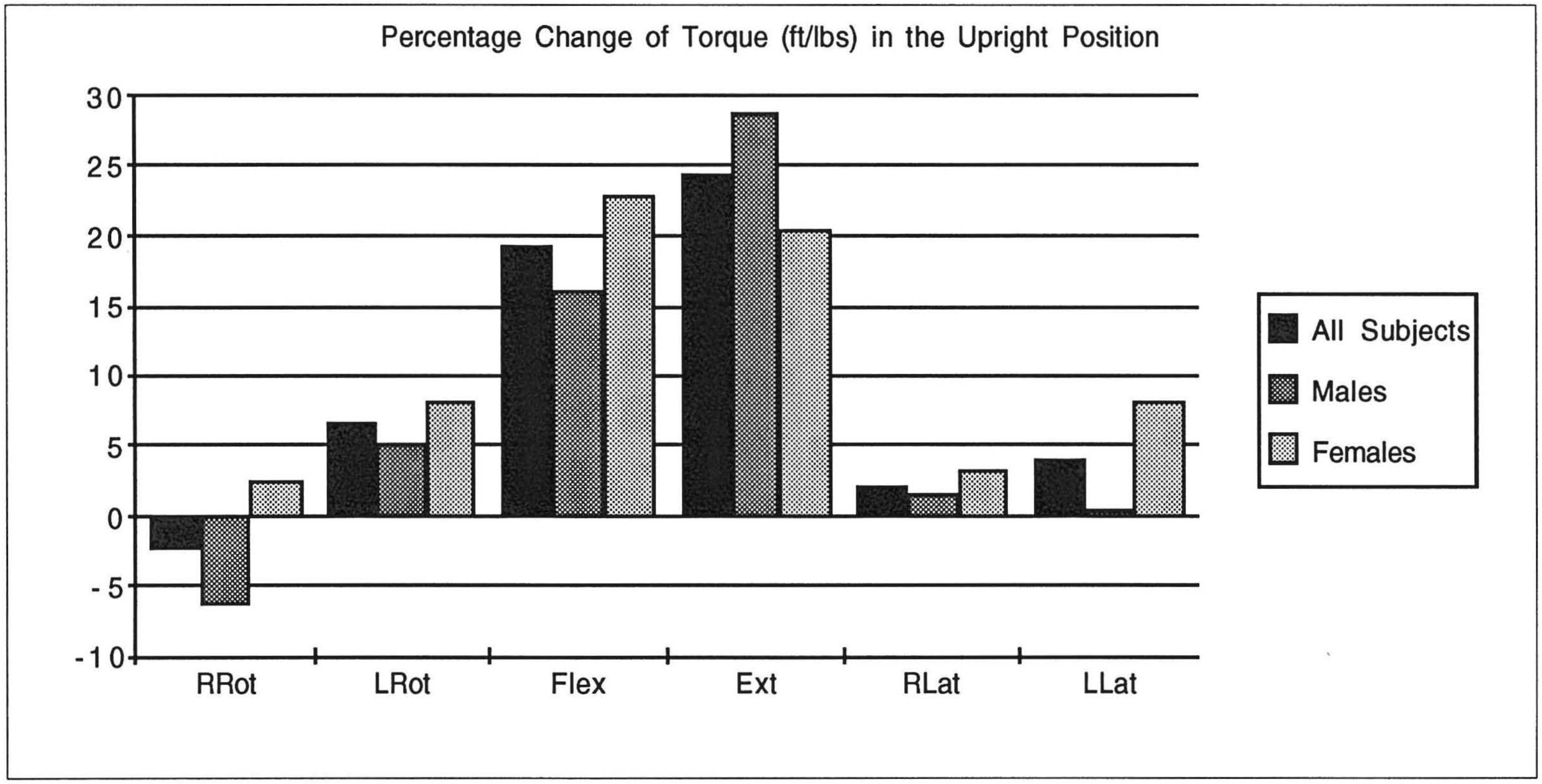
Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\overline{x}$	s	$\overline{x}$	s				
Right Rotation	14	30.44	11.12	31.18	16.41	2.45	8.15 - 70.75	-.25	.807
Left Rotation	14	34.04	9.51	36.77	16.17	8.03	15.45 - 65.05	-1.04	.316
Flexion	14	64.59	19.24	79.36	21.86	22.87	41.80 - 119.90	-4.69	.000
Extension	14	90.04	25.62	108.27	22.97	20.24	44.00 - 146.30	-4.08	.001
R. Lat Flexion	14	71.58	12.84	73.78	14.57	3.07	54.70 - 105.45	-1.47	.165
L. Lat Flexion	14	72.89	18.28	78.73	18.23	8.02	48.40 - 122.90	-2.80	.015

Table 7. Isometric Torque in Males
in the Flexed Position for Initial and Retest Dates

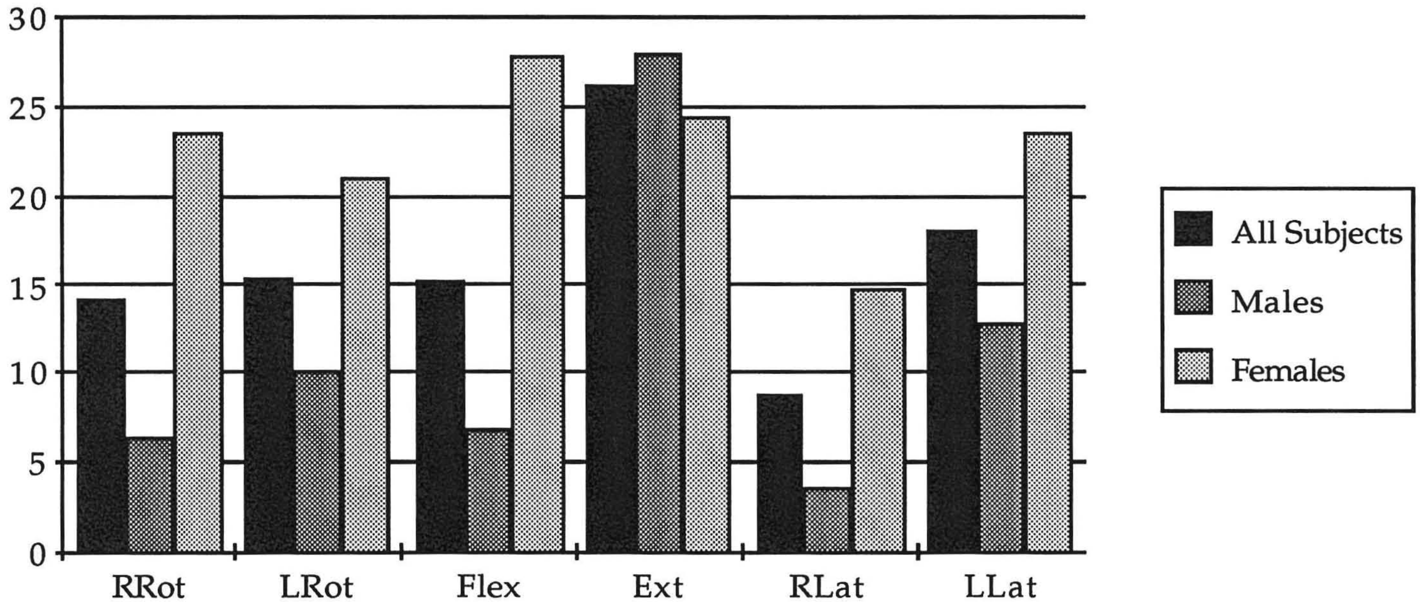
Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\bar{x}$	s	$\bar{x}$	s				
Right Rotation	8	73.60	12.25	78.29	18.46	6.37	42.30 - 99.20	-1.07	.318
Left Rotation	8	69.33	12.62	76.24	17.75	9.97	43.90 - 96.00	-1.48	.182
Flexion	8	147.95	53.14	157.85	31.57	6.69	83.60 - 237.60	-1.06	.323
Extension	8	168.58	38.16	215.60	37.41	27.90	101.20 - 255.20	-6.70	.000
R. Lat Flexion	8	149.83	23.34	155.00	24.99	3.46	109.40 - 176.00	-1.75	.124
L. Lat Flexion	8	129.80	31.22	146.48	30.84	12.85	71.40 - 174.40	-2.39	.048

Table 8. Isometric Torque in Females
in the Flexed Position for Initial and Retest Dates

Motion	N	Initial $\bar{x}$	Initial s	Retest $\bar{x}$	Retest s	% Change	Range	T-value	p
Right Rotation	14	34.74	7.64	42.87	14.60	23.42	22.80 - 74.80	-2.61	.022
Left Rotation	14	35.90	8.19	43.44	10.92	21.00	17.90 - 66.70	-3.31	.006
Flexion	14	65.06	17.49	83.13	18.39	27.77	44.00 - 116.60	-4.52	.001
Extension	14	93.81	19.50	116.52	34.75	24.20	12.10 - 151.80	-2.81	.015
R. Lat Flexion	14	73.18	10.75	83.94	15.32	14.70	52.30 - 112.60	-4.23	.001
L. Lat Flexion	14	71.81	12.37	88.57	19.23	23.33	46.00 - 117.30	-5.65	.000


Percentage Change of Torque (ft/lbs) in the Upright Position
30
25
20
15
10
5
0
-5
-10
RRot
LRot
Flex
Ext
RLat
LLat
All Subjects
Males
Females

Percentage Change of Torque (ft/lbs) in the Flexed Position



decrease in right rotation does not appear to be due to one or two subjects performing significantly poorly on this task as compared to the others.

The subjects were also divided into two age groups to determine if age was a possible factor in performance. Table 9 depicts those subjects below thirty years of age, and Table 10 illustrates those subjects equal to and greater than thirty years of age for the upright position. The subjects less than thirty years exhibited a significant increase in performance for trunk flexion, extension, and left lateral flexion. The subjects equal to and greater than thirty years of age also showed a significant increase in trunk flexion and extension.

Tables 11 and 12 represent the statistics for age groups in the twenty degree position. Subjects less than thirty years showed a significant increase in performance for all motions except flexion. The greater than and equal to thirty years of age group demonstrated a significant increase in flexion, left rotation, and left lateral flexion.

Statistical tests were not conducted on activity levels versus percent change in mean torque values due to the small group sizes present.

Table 9. Isometric Torque for Ages Less Than Thirty Years in the Upright Position for Initial and Retest Dates

Motion	N	Initial $\bar{x}$	Initial s	Retest $\bar{x}$	Retest s	% Change	Range	T-value	p
Right Rotation	14	45.02	19.86	43.32	20.02	-3.92	18.70 - 80.50	.63	.540
Left Rotation	14	47.22	17.26	48.67	19.33	3.07	19.50 - 84.55	-.51	.616
Flexion	14	92.48	50.19	107.25	51.92	15.97	44.00 - 217.80	-5.41	.000
Extension	14	123.67	39.31	152.59	54.43	23.38	79.20 - 248.60	-4.07	.001
R. Lat Flexion	14	98.31	43.75	100.06	42.73	1.78	54.70 - 188.70	-.57	.581
L. Lat Flexion	14	93.50	34.44	99.84	34.69	6.79	48.40 - 163.30	-2.43	.031

Table 10. Isometric Torque for Ages Thirty and Above in the Upright Position for Initial and Retest Dates

Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\bar{x}$	s	$\bar{x}$	s				
Right Rotation	8	40.04	21.51	40.45	23.10	1.01	8.51 - 72.35	-.10	.924
Left Rotation	8	40.04	19.52	45.54	27.97	13.72	15.45 - 82.10	-1.29	.237
Flexion	8	83.88	38.03	105.05	34.29	25.25	41.80 - 167.20	-3.94	.006
Extension	8	99.55	55.41	126.36	57.07	26.93	56.10 - 225.50	-4.60	.002
R. Lat Flexion	8	98.61	37.79	101.29	40.10	2.72	55.50 - 173.65	-1.01	.347
L. Lat Flexion	8	96.92	37.63	96.43	38.83	.50	56.30 - 158.55	.10	.926

Table 11. Isometric Torque for Ages Less Than Thirty in the Flexed Position for Initial and Retest Dates									
Motion	N	Initial		Retest		% Change	Range	T-value	p
		x	s	x	s				
Right Rotation	14	51.35	20.57	58.32	24.07	13.58	24.40 -84.55	-2.28	.040
Left Rotation	14	51.00	18.39	58.08	19.91	13.88	34.02 - 92.70	-2.67	.019
Flexion	14	102.61	61.05	112.51	49.51	9.65	44.00 - 237.60	-1.78	.098
Extension	14	132.00	45.79	165.94	52.57	25.71	85.80 - 255.20	-7.10	.000
R. Lat Flexion	14	101.02	45.30	111.56	42.98	10.44	52.30 - 176.00	-4.65	.000
L. Lat Flexion	14	95.92	36.05	112.59	37.96	17.37	46.00 - 174.40	-4.02	.001

Table 12. Isometric Torque for Ages Thirty and Above in the Flexed Position for Initial and Retest Dates

Motion	N	Initial		Retest		% Change	Range	T-value	p
		$\bar{x}$	s	$\bar{x}$	s				
Right Rotation	8	44.53	23.18	51.25	23.17	15.10	22.80 - 87.80	-1.45	.189
Left Rotation	8	42.90	20.51	50.63	23.28	18.01	17.90 - 96.00	-1.95	.093
Flexion	8	82.23	34.12	106.43	33.26	29.43	52.80 - 171.60	-4.75	.002
Extension	8	101.75	40.83	129.11	68.28	26.89	12.10 - 239.80	-1.78	.119
R. Lat Flexion	8	101.10	34.93	106.65	35.84	5.49	68.20 - 176.00	-1.50	.177
L. Lat Flexion	8	87.61	35.21	104.45	36.78	19.22	53.90 - 160.10	-3.64	.008

DISCUSSION

The results of this research project indicate that there is an increase in performance, which I hypothesize to be a "learning effect", for normal subjects between the first and second test sessions on the Isostation B-200. These results are in agreement with several other studies which have noted a general trend for increased torque values between first and second test data on isoinertial and isokinetic machines.[4,9,11,12,16-19]

The results demonstrate a larger percent change in the forward flexed position, thus indicating the possibility of position dependent "learned" performance. In the review of current literature, no other study was found which discussed retest data for isometric strength in the forward flexed position (althougth one study has reported a significant increase in isometric torque for all trunk motions in the forward flexed position as compared to the upright position).[20] In our study, the increase in performance for bilateral rotation and lateral flexion values may be due to the initially unfamiliar position of being locked into twenty degrees of trunk flexion with the knees straight. In this case, an increase in performance might be expected to be greater than in the more common position of standing upright.

In the upright position, Cooke et al[16] found a significant increase in performance ($p<.05$) in their control group between first and second test sessions with no significant increases between the second and third sessions (characteristic of a learning effect). This increase was found in ten out of fifteen variables tested. However, they did not specify if the increases were for isometric, dynamic, or range of motion measurements. Their patient population exhibited a significant increase in performance for all isometric trunk motions. They found a ten percent increase between all four test sessions. This linear increase depicted by their patient population does not show the usual representation of learned behavior, which is demonstrated by an increase in performance followed by a plateau.

One drawback of this study is the fact that only two test sessions were performed. One definition states that "motor learning is said to have occurred if a changed pattern of performance is seen on serial testing. The performance must improve, persist at the improved level, and show decreasing variability over time".[16] Three or four test sessions would have been needed in this study, to demonstrate a plateau in performance.

Montain et al[17] found that isometric trunk flexion and bilateral rotation values were significantly higher ($p<.05$) on repeat testing with the Isostation B-200. Utilizing within subject coefficient of variation statistics, their results suggest that an individual's test score will vary 6.3 - 9.5% between days without intervention. This is similar to my average percent increase in torque values for all trunk motions for the upright position (9.03%). However, I found significant increases for trunk flexion and extension, whereas their significant increases were for flexion and bilateral rotation. Also, my percent increases were much higher for trunk flexion and extension (19.14% and 24.50%, respectively) when compared to theirs (9.3% and 8.3%, respectively).

The differences between the two studies could be due to variations in the protocol utilized. Their exact protocol was not mentioned in this abstract, but they used forty subjects (20 male and 20 female), tested on four occasions with three trials per visit. This increase in the number of trials performed may decrease the variability in measurements between test dates.

Newton et al[12] found a significant increase in performance between first and second test sessions on the Cybex II back testing system (an isokinetic device) with TEF extension and rotation at all speeds for both normal subjects and patients. They did not find a significant increase for trunk flexion and attributed this to possibly reflecting the "relatively strange and unpracticed nature of extension and rotation compared with the more 'natural' flexion".[12] They also stated a larger percent increase in the patient population than in normal subjects, which they postulated as being due to the patients learning about their low back pain as well as learning of the test technique.

Only one contradictory study was found in the literature. A study by Szpalski and Hayez was reported to have opposing data to a learning effect.[4] However, this study could not be obtained as a reference as it was unpublished.

My research also indicated a larger percent difference between trial one and trial two for females as compared to males. This was found in both the upright and flexed positions, and for all motions with the exclusion of trunk extension. In their study, Szpalski et al[19] found that percentage differences in repeated trials were independent of the gender of the subject. The variation between the results could be due to the small sample size utilized in my research (14 females and 8 males) as compared to their sample population (39 females and 53 males). Alternatively, it may also be due to the testing protocol. Subjects in my study were retested between forty-eight and ninety-six hours post-initial test. In their study, subjects were retested during the same test period, possibly decreasing the variability of test scores due to fatigue during the test session.

I did not find age to be a determining factor in the consideration of a learning effect. No other studies were found that looked at variations in retest performance due to age differences, and it did not appear it played a determining role in this study.

CLINICAL IMPLICATIONS

When testing normal subjects on the Isostation B-200, it seems there is the potential for significant increases in performance between first and second test sessions even when a pretest is utilized. It also appears that there are differences in learned performance that are position dependent. Overall, the results of this study indicate that the flexed position yielded larger increases in performance, or "learning", than did the upright position. However, there may be variances between each trunk motion.

The results also suggest that there is a larger "learning effect" in females than there is in males. This was found in both the upright and flexed positions. There was not a significant discrepancy between the two age groups.

Based upon this study, clinicians finding a change in performance ranging from -2.20 - 24.50% (avg. = 9.03%) in the upright position and 8.64 - 26.07% (avg. = 16.19%) in the flexed position, should realize that their results may be indicative of an increase in performance unrelated to their specific rehabilitation program. Results yielding a larger increase in torque values may be attributable to other factors, including actual strength gains.

APPENDIX

_X_ EXPEDITED REVIEW REQUESTED UNDER ITEM _3_ (NUMBER[S]) OF HHS REGULATIONS

__ EXEMPT REVIEW REQUESTED UNDER ITEM ____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Stephanie Kyes **TELEPHONE:** 775-3857 **DATE:** 9/12/94

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: 815 Duke Drive #212, Grand Forks, ND 58201

SCHOOL/COLLEGE: UND **DEPARTMENT:** Physical Therapy **PROPOSED PROJECT DATES:** 10/1/94 - 3/1/95

PROJECT TITLE: The Effects of Repeat Testing on Performance Scores Utilizing the Isostation B-200

FUNDING AGENCIES (IF APPLICABLE): ____

TYPE OF PROJECT:
__ NEW PROJECT __ CONTINUATION __ RENEWAL __ DISSERTATION OR THESIS RESEARCH _X_ STUDENT RESEARCH PROJECT

__ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Tom Mohr, Ph.D.

PROPOSED PROJECT: __ INVOLVES NEW DRUGS (IND) __ INVOLVES NON-APPROVED USE OF DRUG _X_ INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

_ MINORS (<18 YEARS) _ PREGNANT WOMEN _ MENTALLY DISABLED _ FETUSES _ MENTALLY RETARDED

_ PRISONERS _ ABORTUSES _X_ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ____

1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

Low back pain (LBP) is a nationwide medical and socioeconomic problem. It is estimated that LBP will affect eight out of ten people in the United States at some point in their life. As a result, much research and technology has been devoted to developing a machine that will produce objective findings on the functional capacities of trunk musculature. The Isostation B-200 (Isotechnologies, Inc., Carrboro, NC) is one such machine.

The Isostation B-200 is an isoinertial machine - that is, it measures strength against a preset resistance where the velocity varies with the amount of force produced by the subject. The B-200 also has the capability to simultaneously measure movement about all three axes of motion - flexion/extension, rotation, and lateral flexion.

Both isokinetic and isoinertial machines have been documented as having a "learning effect" between the first and second test sessions. Many studies recommend a second iso-test session, performed on a separate day, to be used as the baseline measure, to allow for such an effect. However, none of these studies used data from a second test session as their baseline.

The purpose of this research project is twofold: 1) to determine if there is a significant increase in performance, or learning effect, between the first and second test sessions on the Isostation B-200 for normal subjects; and 2) if so, is there a specific percentage of increase that can be attributed as a learning effect for each age category and/or activity level.

The results of this study will help medical professionals accurately monitor the progress of their LBP patients and the effectiveness of their treatment programs.

Sixty or more human subjects ranging in age from 18 to 56 years with no prior history or treatment for LBP will be used for this study. They will be asked to perform two test sessions on the Isostation B-200.

PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

All subjects will be on a voluntary basis in which they may withdraw from the study at any time. Subjects will be recruited from the Medical Center Rehabilitation Hospital and the University of North Dakota, due to the close relationship between the two institutions. Prior to the first test, each subject will be asked to complete a consent form, health history form, and an activities rating scale.

The health history form will be used to screen subjects with any of the following medical conditions: treatment/diagnosis of LBP, herniated nucleus pulposus, diabetes, rheumatoid arthritis, previous spinal fracture, neurologic deficit, inflammatory spondylarthropathy, history of smoking/substance abuse, or other active medical disease.

Each subject will be asked to fill out a brief questionnaire to estimate levels of activity at work and leisure. Demographic information, such as age, weight, height, and gender will also be collected at the time of initial testing.

To ensure accuracy of the test results, each subject will be asked to avoid activities outside their normal routine throughout their participation in this study, and also avoid athletic activity 4 hours prior to the test sessions. Subjects will be retested between 48 and 96 hours post-initial testing to allow recovery from post-exercise muscle soreness.

Subjects will be introduced to the Isostation B-200 by one of the project directors and any questions will be answered. Subjects will be tested in two positions. First, in an upright, standing position with the flexion/extension axis of the machine aligned with the subject's lumbosacral junction. The subject will be firmly stabilized by chest and pelvic pads, and additional straps secured at the knees and thighs, according to the manufacturer's protocol. For the second test position, the subject will be locked into 20 degrees of flexion. The subject will be asked, via audiotape, to perform 2 maximal isometric contractions in each direction of the sagittal, coronal, and transverse planes for both test positions. The subject will be asked to exert steady maximum effort until he/she is asked to relax. To ensure the safety of the subject and the validity of the data, the subject will be warned against jerky exertion.

All data will be collected by computer and stored on floppy disk. The software collects and displays the torque, angular position, and velocity for each axis.

The resulting data will also be statistically analyzed using t-tests, analysis of variance, and/or correlation analysis.

3. BENEFITS: (Describe the benefits to the individual or society.)

The benefits of this study include providing more accurate test results which medical professionals can use to monitor the patient's progress. Therapists can also monitor the effectiveness of their treatment programs which will help them provide the best possible exercise program for each patient.

The ability to use first test session data minus the percentage of "normal" learning effect will not only save health care agencies money, but will also save the patient time and the extra expense of having a repeat test for baseline data.

The subject being tested may also be provided a copy of his/her test results which could provide valuable baseline information if ever needed.

4. RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psycho-logical, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

Subjects may experience some pain and/or delayed onset muscle soreness (DOMS) as a normal result of exercise. The second test session will be scheduled at least 48 hours post-initial testing to allow one day of rest between sessions to reduce post-exercise muscle soreness.

The protocol will consist of isometric, or stationary, contractions to minimize the risk of injury to the trunk due to motion. Subjects will also be instructed that they may stop at any time during the test session, should they experience any undue discomfort.

The risks to the subject are expected to be minimal. This particular machine is used to test patients at the MCRH on a daily basis with very few problems. The B-200 is a strength testing apparatus that is commonly utilized throughout the United States in physical therapy departments.

5. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

The signed consent forms from this study will be kept at the University of North Dakota - Physical Therapy department, in care of Thomas Mohr, P.T., Ph.D.

6. For **FULL IRB REVIEW** forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Box 8138, University Station
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

- -

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

______________________________ **DATE:**______________
Principal Investigator

______________________________ **DATE:**______________
Project Director or Student Adviser

______________________________ **DATE:**______________
Training or Center Grant Director

ACKNOWLEDGMENT

I hereby acknowledge and offer my full support of the research project entitled The Effects of Repeat Testing on Performance Scores Utilizing the Isostation B-200.

John Zeller, MD	10/5/94
	Date

ACKNOWLEDGMENT

I hereby acknowledge and offer my full support of the research project entitled The Effects of Repeat Testing on Performance Scores Utilizing the Isostation B-200.

Jack Carroll, PhD   12/5/94
Date

CONSENT FORM:
RESEARCH PROJECT UTILIZING THE ISOSTATION B-200

Names of project directors: Stephanie Kyes, S.P.T. and Schawnn Decker, M.P.T

You have been asked to participate in a research study using the Isostation B-200. The B-200 is a machine used to measure strength of trunk musculature. It is commonly utilized in physical therapy departments throughout the United States, and is used to test patients on a daily basis at the MCRH. The results of this study may help medical professionals accurately monitor the progress of their patients with low back pain and the effectiveness of their treatment programs.

Prior to testing, you will be asked to fill out a health history form to screen for contraindications to testing. You will also be asked to fill out a brief questionnaire to estimate levels of activity, both at work and leisure.

You will be asked to perform two test sessions on the Isostation B-200, the duration of each session is approximately one-half hour. You will be tested in two positions. The first is in an upright, standing position. You will be firmly stabilized in the machine by chest and pelvic pads, and additional straps around the thighs and knees, according to the manufacturer's protocol. For the second test position, you will be locked in 20 degrees of forward bending. The test protocol will be given to you via audiotape. You will be asked to perform 2 maximal contractions for both test positions against the machine in each of six directions: forward bending, backward bending, rotation right/left, and side bending right/left.

The second test session will be scheduled between 48 and 96 hours after the initial test. This will allow recovery time from any post-exercise muscle soreness you may experience.

Testing will take place only when other medical personnel are in the building, and you will be monitored by a trained evaluator throughout the test sessions to avoid risk of injury. Should any adverse reaction occur, the testing session will be terminated.

This is a non-invasive procedure, but, as with any form of exercise, there is a slight risk of muscle soreness following the procedure. Should injury occur, you and your medical insurance agency will be responsible for all costs.

Participation is entirely voluntary and you have the right to withdraw consent and discontinue participation in the study at any time without prejudice to present or future care/employment at the Medical Center Rehabilitation Hospital. There is no cost for any part of the study.

At your request, you will be provided with a copy of your test results.

Information from this study will be anonymously coded to ensure confidentiality and you will not be personally identified in any publication containing the results of this study. Written material from the study will be kept at the University of North Dakota - Physical Therapy department, in care of Thomas Mohr, P.T., PH.D.

Stephanie Kyes, student P.T., University of North Dakota (777-2831), and Schawnn Decker, M.P.T., MCRH (780-2315) will be available to answer any questions you may have concerning the study, the procedures, and any risks or benefits that may arise from participating in this study.

I have fully explained to______________________ the nature and purpose of the above-
PARTICIPANT
described procedure and the risks involved in its performance. I have answered all questions to the best of my ability. I will inform the participant of any changes in the procedure or the risks and benefits if any should occur during or after the course of the study.

EVALUATOR'S SIGNATURE DATE

I have been satisfactorily informed of the above-described procedure with its possible risks and benefits. I give permission for my participation in this study. All of my questions have been answered to my satisfaction so far, and I know the project directors will be available to answer any questions I may have throughout the course of this study. I understand that I am free to withdraw consent and discontinue participation in this project at any time. I have been offered a copy of this form.

PARTICIPANT'S SIGNATURE DATE

WITNESS DATE

HEALTH HISTORY QUESTIONNAIRE

Name: ____________________ **Age:** ______________ **Gender:** ____________ **Date:** ______________

Height: ___________________ **Weight:** ___________ **Occupation:** _____________________________

Do you now, or have you ever had any of the following conditions:

YES	NO		YES	NO	
____	____	Heart Attack	____	____	Allergies
____	____	Angina/Chest pain	____	____	Shortness of breath
____	____	Cardiovascular disease	____	____	Recent surgery
____	____	Irregular heart beat	____	____	Recent fractures
____	____	Emphysema	____	____	Herniated disk
____	____	Asthma	____	____	Treatment of low back pain
____	____	High blood pressure	____	____	Severe osteoporosis
____	____	Low blood pressure	____	____	Currently pregnant
____	____	Diabetes	____	____	Chemical dependency (i.e., alcoholism)
____	____	Blackouts	____	____	Smoker
____	____	Rheumatoid Arthritis	____	____	Other medical disease
____	____	Other arthritis			

List any prescription medications you are currently taking: ____

____

Blood Pressure: before__________ Heart Rate: before__________

after ___________ after __________

ACTIVITIES QUESTIONNAIRE

		Activity	# times/week
1.	List the competitive sports you currently participate in, if any. (For example: college or professional football, hockey, baseball, basketball ...)	1)____________________	_______
		2)____________________	_______
		3)____________________	_______
		4)____________________	_______
2.	List the recreational sports you currently participate in, if any. (For example: jogging, biking, hiking, skiing, swimming, volleyball, basketball, softball, weight lifting, aerobics...)	1)____________________	_______
		2)____________________	_______
		3)____________________	_______
		4)____________________	_______
		5)____________________	_______
3.	List the specific trunk strengthening activities you participate in, if any. (For example: sit-ups, crunches, lateral pull-downs, rowing, back extension, squats, ...)	1)____________________	_______
		2)____________________	_______
		3)____________________	_______
		4)____________________	_______
		5)____________________	_______
		6)____________________	_______

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